Tektronix®

High Slew-Rate Regenerative Testing of Data Center Power Supplies

TECHNICAL BRIEF

Elektro-Automatik

Introduction

Modern data-center power shelves are being pushed far beyond traditional design assumptions, largely due to the erratic and burst-heavy power profiles of AI accelerators and high-performance computing (HPC) clusters. Unlike conventional server loads, these systems can swing from idle to peak consumption in microseconds, forcing power delivery networks to respond with exceptional speed and accuracy.

As a result, validation and test equipment must evolve accordingly, delivering ultra-fast current slew rates that mimic real-world transients, while maintaining precise control over complex load waveforms. Engineers need to reproduce dynamic behaviors such as GPU workload spikes, voltage droop events, and recovery characteristics under tightly controlled conditions.

At the same time, the electrical environment itself is becoming more demanding. Higher rack power densities and the shift toward 800 V introduce new challenges in terms of insulation, thermal management, and measurement accuracy. Test systems must remain stable and reliable even when operating at kilowatt-level power and elevated voltages, where small instabilities can cascade into significant errors or hardware stress. In this context, modern power testing solutions have become a central enabler of data-center reliability, efficiency, and scalability in the AI era.

Tektronix Solution for Data Center Power Testing

Tektronix introduces the EA-ELR 21000 dynamic test system to address the growing need for realistic, high-stress validation of modern power infrastructure, where rapid load transients and extreme power densities are the norm rather than the exception. The system is built around the high-performance ELR 21000-80 electronic load units, engineered for exceptionally fast current transitions, enabling engineers to accurately emulate the demanding behavior of hyperscale data center loads. Unlike conventional dissipative loads that convert test energy into waste heat—and therefore require oversized cooling and higher facility power budgets, these regenerative DC loads recover and return up to 95% of the absorbed energy back to the microgrid. This regenerative approach delivers immediate operational benefits, lowering energy consumption, reducing thermal stress on the test environment, and significantly cutting operating costs. From a performance standpoint, the test system supports truly dynamic testing up to 1000 V and up to 1.92 MW, with current slew rates reaching 12 A/µs at 240 kW, making it well suited for validating power supplies, rectifiers, and distribution equipment under real-world transient conditions. This tech brief focuses on how to configure the system and apply the correct practices to reliably achieve such high dynamic performance, highlighting that, at these slew rates, mechanical layout, cabling, and grounding become just as critical as the electronic capabilities of the load itself.

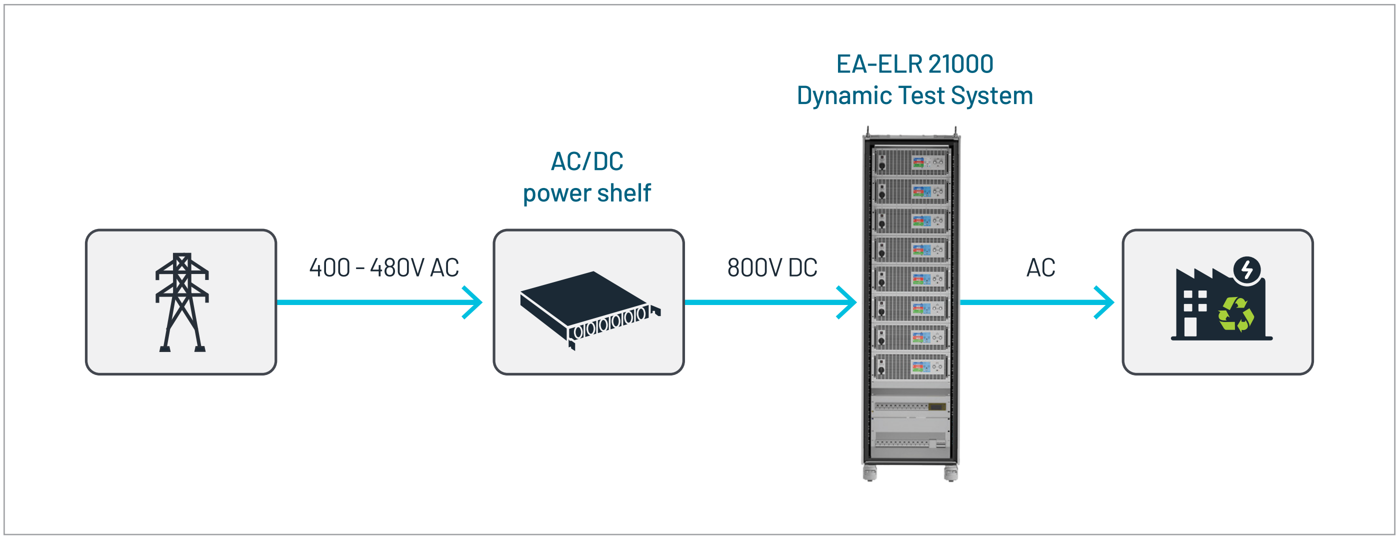

Figure 1: Common scheme of a data center power system, from grid to rack and microgrid.

General Data Center Power System Configuration

To validate a typical modern AC/DC power shelf under realistic operating conditions, a 400–480 V AC source is used to supply the unit under test, which converts the incoming AC power into a high-voltage 800 V DC output as common in today's data center architectures. This DC output is then directly connected to the ELR 21000 dynamic test system, where the electronic loads precisely emulate downstream data center demand. A key advantage of this setup is the system's regenerative capability: instead of dissipating the absorbed power as heat, up to 95% of the energy is fed back into the microgrid, dramatically improving overall test efficiency and minimizing facility power and cooling requirements. From a system design perspective, the test equipment must be capable of safely sinking the full output power of the AC/DC shelf while also providing sufficient voltage headroom to ensure stable and reliable operation during dynamic events. With a maximum rating of up to 1000 V, the ELR 21000 dynamic test system comfortably exceeds the 800 V DC output of high-power shelves, making it well suited for both steady-state and transient testing. This voltage margin not only enhances safety but also ensures accurate reproduction of real-world operating conditions, even during fast load steps and fault scenarios where voltage excursions can occur.

Best Practices and Methodologies Adopted

Connecting each ELR 21000-80 module directly to the DUT

To achieve the highest possible current slew rate, each ELR 21000-80 load within the rack must be connected directly to the device under test (DUT) using individual power cables. This point is critical because, at very high dynamic speeds, the electrical behavior of the interconnection becomes a dominant factor in overall system performance. Direct cabling minimizes parasitic inductance and resistance in the current path, allowing the load to respond almost instantaneously to command changes. In contrast, interconnecting multiple EA DC loads via a shared copper busbar introduces additional impedance and distributed inductance, which act as a limiting factor during fast current transitions. As a result, the system's ability to achieve steep current ramps is compromised, leading to slower effective slew rates and less accurate emulation of real-world load transients. For high-dynamic testing and especially when targeting slew rates in the multi-ampere-per-microsecond range—the physical layout and wiring strategy are therefore just as important as the electronic specifications of the load itself, making direct, point-to-point connections to the DUT the preferred and recommended approach.

Cables resistance and inductance

When operating at very high current slew rates, the electrical characteristics of the cabling become a decisive factor in preserving test accuracy and repeatability. A large cable cross-section is therefore essential, as it directly reduces both resistance and inductance in the current path, ensuring that the resulting current waveform closely follows the commanded profile without distortion. A thicker conductor lowers the cable's resistance, minimizing I·R voltage drops that would otherwise become pronounced during fast current transients and potentially compress or deform the intended load step. At the same time, increasing the cross-section helps reduce the effective inductance of the connection—an especially critical consideration at high slew rates, where even small parasitic inductances can generate substantial L·di/dt voltage spikes that limit dynamic performance and introduce measurement artifacts.

Cable length and physical routing further influence these effects. To maintain optimal dynamic behavior, a maximum cable length of 3 meters per device is recommended, combined with a minimum cross-section of 25 mm^2. Shorter cables reduce both resistive losses and loop inductance. Furthermore, the use of separate and tightly twisted-pair cable for each device is recommended, improving the achievable current slew rate. In practice, careful attention to cable pairing, routing, and twisting is just as important as conductor size when pushing into the multi-ampere-per-microsecond regime.

In summary, the following installation guidelines should be observed to achieve the best dynamic performance:

- Connect each electronic load unit individually to the DUT using dedicated positive and negative cable pairs in a star configuration.
- Limit cable length to a maximum of 3 meters per device whenever possible.
- Use power cables with a cross-section of at least 25 mm^2.
- Route positive and negative conductors twisted together.

Adhering to these recommendations ensures that the cabling does not become the limiting factor, allowing the full dynamic capability of the ELR 21000 dynamic test system to be realized during high-slew-rate testing.

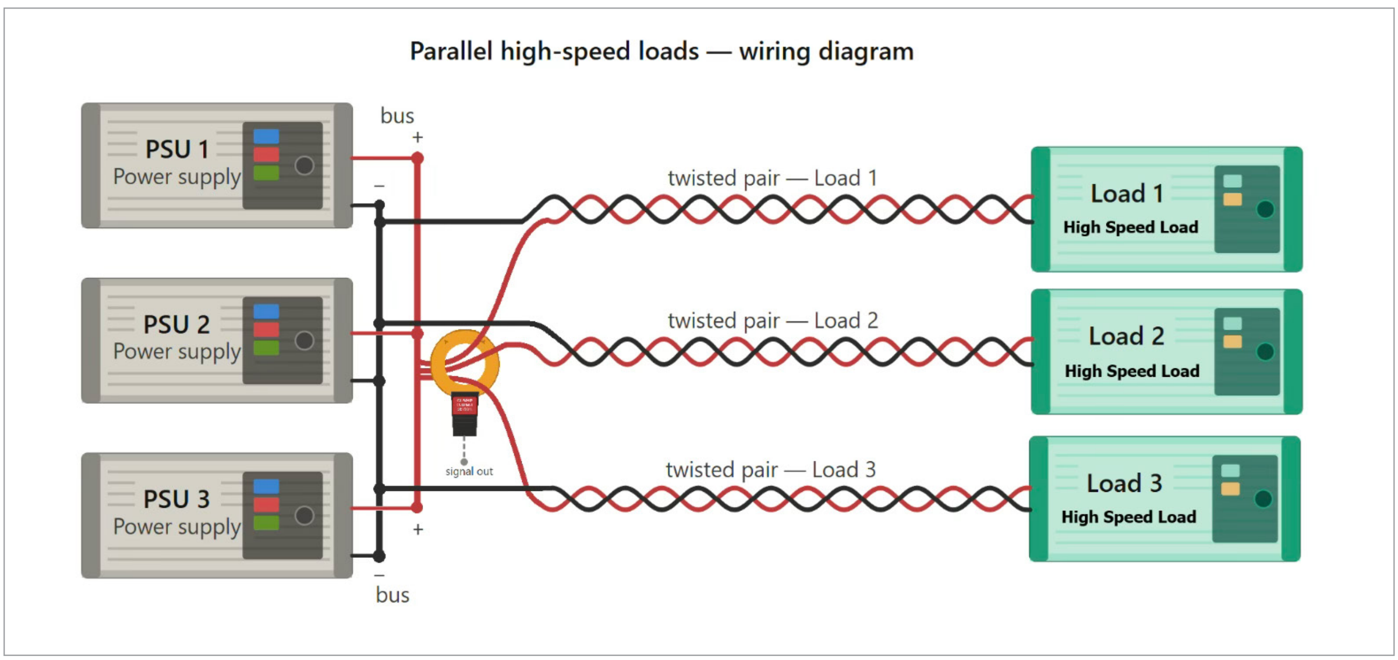

Figure 2: Correct parallel wiring.

Operations and control

The system offers flexible control options to accommodate a wide range of test environments, user preferences, and levels of automation. It can be operated locally through the integrated HMI, enabling engineers to configure parameters, monitor measurements, and execute tests directly at the rack with immediate visual feedback. For more advanced workflows, EA's Power Control software provides centralized control, data logging, and test sequencing, making it well suited for laboratory use, validation campaigns, and repeatable characterization tasks. In automated test setups or production environments, the system can also be fully controlled via industry-standard command interfaces such as SCPI and ModBus. Support for these widely adopted protocols allows seamless integration into existing test frameworks, ATE systems, and higher-level control architectures, ensuring that the ELR 21000 dynamic test system can scale from manual bench testing to fully automated, remotely managed test operations without changes to the underlying hardware.

EA Power Control software is designed to enable a fast and intuitive startup while still offering the depth required for advanced power testing. Its built-in function generator allows users to quickly apply common dynamic load profiles—such as sine, triangle, rectangular, or trapezoidal waveforms—without the need for external signal sources or custom scripting. This makes it easy to simulate real-world operating conditions, including periodic load variations and sharp transient events, directly from the software interface. In addition, the software supports the creation and management of test sequences, allowing repeated or long-term tests to be saved, recalled, and executed consistently. By eliminating the need to reconfigure parameters for each test run, this capability not only reduces setup time but also improves repeatability and overall test efficiency, making the software well suited for both development labs and validation environments where productivity and consistency are critical.

Once the software is running, the user simply opens the function generator from the main interface, where a dedicated control window provides access to a range of predefined waveform shapes. Common profiles such as sine, triangle, rectangular, and trapezoidal waveforms can be selected directly, allowing engineers to focus on the test objective rather than on low-level setup details.

After choosing the desired waveform—for example, a trapezoidal profile suited to fast load-step testing—the configuration naturally follows a logical flow. The first stage defines how the waveform is applied by selecting the operating mode, such as voltage or current control, depending on whether the test aims to stress regulation or dynamic response. The second stage then allows fine adjustment of the waveform characteristics, including timing parameters, amplitude, and offset. This makes it easy to tailor the signal to match real-world operating conditions, from gentle periodic variations to aggressive transient events.

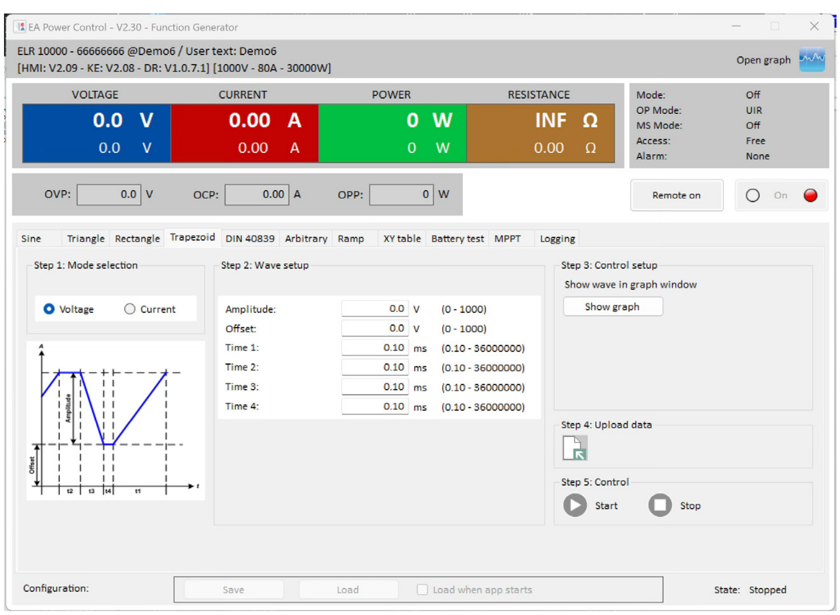

Figure 3: Common user interface offered by the EA Power Control software

Conclusion

The Tektronix ELR 21000 dynamic test system provides a purpose-built, highly efficient platform for validating modern high-voltage, high-power data center equipment under realistic and demanding conditions. By combining regenerative electronic loads with exceptional dynamic performance, the system enables engineers to reproduce fast load transients while dramatically reducing energy consumption and cooling requirements. Careful attention to system configuration—particularly cabling topology, conductor sizing, physical layout, and installation practices—is essential to fully realize current slew rates up to 12 A/µs at 240 kW and ensure repeatable, distortion-free results. Flexible control options and full automation via EA Power Control software and standard command interfaces, further enhance usability across development, validation, and production environments. Together, these capabilities make the ELR 21000 dynamic test system a scalable and future-proof solution for testing next-generation power shelves and data center power architectures with both precision and efficiency.

Contact Information:

Australia 1 800 709 465

Austria* 00800 2255 4835

Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777

Belgium* 00800 2255 4835

Brazil +55 (11) 3530-8901

Canada 1 800 833 9200

Central East Europe / Baltics +41 52 675 3777

Central Europe / Greece +41 52 675 3777

Denmark +45 80 88 1401

Finland +41 52 675 3777

France* 00800 2255 4835

Germany* 00800 2255 4835

Hong Kong 400 820 5835

India 000 800 650 1835

Indonesia 007 803 601 5249

Italy 00800 2255 4835

Japan 81 (3) 6714 3086

Luxembourg +41 52 675 3777

Malaysia 1 800 22 55835

Mexico, Central/South America and Caribbean 52 (55) 88 69 35 25

Middle East, Asia, and North Africa +41 52 675 3777

The Netherlands* 00800 2255 4835

New Zealand 0800 800 238

Norway 800 16098

People's Republic of China 400 820 5835

Philippines 1 800 1601 0077

Poland +41 52 675 3777

Portugal 80 08 12370

Republic of Korea +82 2 565 1455

Russia / CIS +7 (495) 6647564

Singapore 800 6011 473

South Africa +41 52 675 3777

Spain* 00800 2255 4835

Sweden* 00800 2255 4835

Switzerland* 00800 2255 4835

Taiwan 886 (2) 2656 6688

Thailand 1 800 011 931

United Kingdom / Ireland* 00800 2255 4835

USA 1 800 833 9200

Vietnam 12060128

*** European toll-free number. If not accessible, call:** +41 52 675 3777

Rev. 02.2022

Elektro-Automatik

Find more valuable resources at [TEK.COM](https://www.tek.com)

082826 SBG 1EW-74271-0